5. REMEDIAL ACTION OBJECTIVES

Remedial action objectives were defined in the 1995 ROD to specify expected remedy performance during the three phases of remedy implementation. One RAO was defined for Phase A, one for Phase B, and one for Phase C. A separate RAO was defined for the institutional controls to ensure the controls remained in place during the life of the remedial action. Phase A and B activities were designed to meet the respective RAOs. Changes documented in the ESD (INEEL 1997 [INEEL/EXT-97-00931]) and the results of the treatability studies led to a revision of the Phase C RAOs. In addition, for all sites within WAG 1, institutional controls are being implemented in accordance with the OU 1-10 ROD (DOE-ID 1999a [DOE/ID-10682]).

5.1 Remedial Action Objectives Defined in the 1995 ROD

The RAOs defined in the 1995 ROD (Section 9.2) included specific objectives for each of the three phases and for institutional controls, as follows:

> "Phase A – Remove as much of the secondary source as possible from the vicinity of the TSF-05 Injection Well by physically and hydraulically stressing the well. The treatment system shall be designed such that concentrations of VOCs in the effluent are below MCLs before reinjection into the hot spot. All attempts will be made to operate this process as a hydraulically contained system. The air pollution control device will be operated in compliance with ARARs. Continue surging and stressing the well for 15 months unless Phase B is ready to begin before this date.
>
> "Phase B – Prevent, to the maximum extent practicable, migration of contaminated groundwater beyond the hot spot at levels above MCLs, or for those contaminants for which an MCL does not exist, [ensure that] the contaminant concentration will be such that the total excess cancer risk posed by release of contaminated groundwater will be within the acceptable range of 10^{-4} to 10^{-6}. For aboveground treatment processes using reinjection of treated effluent, treatment shall, at a minimum, be sufficient to reduce the VOC concentration to below MCLs. VOCs discharged to the atmosphere from [Groundwater Treatment Facility] operations will not exceed the calculated emission rate limits specified in Table 9-1 [of the 1995 ROD].
>
> "Phase C – Capture and treat a sufficient portion of the dissolved phase plume beyond the hot spot to provide for aquifer cleanup within 100 years of the date of [1995] ROD signature. For aboveground treatment processes using reinjection of treated effluent, treatment shall be designed to reduce the VOC concentration to below MCLs. If an MCL does not exist, the contaminant concentration will be such that the total excess cancer risk posed by the groundwater will be within the acceptable range of 10^{-4} to 10^{-6}. VOCs discharged to the atmosphere from GWTF operations will not exceed the calculated emission rate limits specified in Table 9-1 [of the 1995 ROD].
>
> "Institutional controls and groundwater monitoring – Institutional controls shall be implemented to protect current and future users from health risks associated with ingestion of groundwater containing COC concentrations greater than MCLs or 10^{-4} to 10^{-6} risk-based concentrations for contaminants without MCLs. Institutional controls shall be maintained until COC concentrations fall below MCLs or 10^{-4} to 10^{-6} risk-based concentrations for contaminants without MCLs."

5.2 Refinement of Remedial Action Objectives for Phase C

Changes and results documented in the ESD and the FDR (DOE-ID 2000a [DOE/ID-10718]) prompted a refinement of the Phase C RAOs. The Agencies agreed to the following final RAOs for the entire contaminant plume:

- Restore the contaminated aquifer groundwater by 2095 (100 years from the signature of the 1995 Record of Decision) by reducing all contaminants of concern to below MCLs and a 1×10^{-4} total cumulative carcinogenic risk-based level for future residential groundwater use and, for non-carcinogens, until the cumulative hazard index is less than 1.

- For aboveground treatment processes in which treated effluent will be reinjected into the aquifer, reduce the concentrations of VOCs to below MCLs and a 1×10^{-5} total risk-based level.

- Implement institutional controls to protect current and future users from health risks associated with ingestion or inhalation of or dermal contact with contaminants in concentrations greater than the MCLs or greater than a 1×10^{-4} cumulative carcinogenic risk-based concentration or a cumulative hazard index of greater than 1, whichever is more restrictive. The institutional controls shall be maintained until concentrations of all contaminants of concern are below MCLs and until the cumulative carcinogenic risk-based level is less than 1×10^{-4} and, for non-carcinogens, until the cumulative hazard index is less than 1. Institutional controls shall include access restrictions and warning signs.

Restoration of the hot spot under either the original remedy or the amended remedy will not directly affect radionuclide concentrations in groundwater. The geochemical behavior of the radionuclides in the subsurface acts to bind them to soil and rock in the area where they now are located. This will continue to prevent them from migrating beyond the vicinity of the hot spot and from being available to future drinking water users. This behavior supports the presumption that, throughout the restoration period, radionuclide concentrations in water extracted from the aquifer downgradient from the hot spot will remain below MCLs and 1×10^{-4} cumulative carcinogenic risk-based levels and, for non-carcinogens, the cumulative risk will remain less than 1. Estimates of radionuclide attenuation by sorption and radioactive decay indicate that Cs-137 and Sr-90 will meet RAOs throughout the contaminant plume by 2095. Sorption of radionuclides from the dissolved phase to subsurface materials prevents these radionuclides from being present in the drinking water of future users. The remaining radionuclides (U-234 and tritium) are currently below MCLs and 1×10^{-4} cumulative carcinogenic risk-based levels. Concentrations of these two radionuclides are not expected to increase to levels that would prevent attainment of RAOs as a result of implementation of either ISB or pump-and-treat.

5.3 Responsiveness to Risk of Remedial Action Objectives

The risks identified in the risk assessment will be addressed by reducing all COCs to below MCLs, and 1×10^{-4} cumulative carcinogenic risk-based levels for those constituents without an MCL, and a cumulative hazard index of less than 1.

5.4 Performance Criteria for Remediation Goals

Remediation goals were developed to ensure that the final remedy would restore the plume by 2095. The refined RAOs for the final remedy (defined in Section 5.2) led to specific performance goals for each component of the remedy. Each component of the amended remedy (ISB at the hot spot, pump-and-treat in the Medial Zone, and MNA in the distal zone) will restore the plume by 2095. The general performance criteria for each remedy component are given below. The detailed implementation strategy will be presented in the RD/RA SOW for this ROD Amendment.

5.4.1 In Situ Bioremediation at the Hot Spot

The general performance criteria for ISB consist of collection of monitoring data that demonstrate complete dechlorination of VOCs to prevent, to the maximum extent practicable, migration of VOCs above MCLs beyond the hot spot and to restore the plume by 2095.

5.4.2 Pump-and-Treat in the Medial Zone

*(**Note:** The following restatement drawn from the 1995 ROD is provided only to assist the reader. This ROD Amendment is not modifying or amending the medial zone component of pump-and-treat.)* The general performance criteria for the NPTF consist of completing drawdown measurements to ensure that the contaminated groundwater plume is captured and treated to below MCLs.

5.4.3 Monitored Natural Attenuation in the Distal Zone

The general performance criteria for MNA consist of evaluation of monitoring data to determine (1) whether natural attenuation processes continue to meet the RAO for the distal zone of the plume and (2) that plume expansion does not exceed 30%. Predicted breakthrough curves at a selected set of wells will be compared to groundwater monitoring data. The evaluations will be conducted once every year for the first 5 years (Fiscal Years 2001 through 2005) and at least once every 5 years thereafter. If four consecutive evaluations show that the RAOs will not be met within the restoration timeframe, the contingency remedy for the distal zone of pump-and-treat (i.e., the default remedy described in the 1995 ROD) will be implemented or, if the Agencies concur, a more cost-effective remedy will be identified at the time that the contingency remedy is implemented. If, as a result of a 5-year review, data analysis indicates that the RAO will not be met within the restoration timeframe, additional annual reviews will be conducted until four consecutive evaluations produce the same result.

6. DESCRIPTION OF THE ORIGINAL REMEDY AND AMENDED REMEDY

The treatability studies (described in Section 2.4) demonstrated that an amended remedy incorporating two of the tested technologies would be more effective than the original remedy. This section summarizes the original remedy and the amended remedy and describes the common elements and the distinguishing features of the two alternatives.

6.1 Original Remedy

The original remedy, as described in the 1995 ROD and refined in the ESD (INEEL 1997 [INEEL/EXT-97-00931]), called for groundwater extraction and aboveground treatment for all three zones using three separate pump-and-treat facilities. Two of the three components (pump-and-treat at the hot spot and in the distal zone) are being amended; the medial zone component is not being amended and will be implemented as described in the 1995 ROD. Based on the results of the treatability studies, the decision was made to continue with the default remedy of pump-and-treat for the medial zone. Institutional controls and groundwater monitoring are also not being amended.

6.1.1 Pump-and-Treat in the Medial Zone

In accordance with the original remedy, groundwater extraction and treatment in the medial zone will be carried out at the NPTF. Extraction wells will be located approximately 450 m (1,500 ft) downgradient from the TSF-05 Injection Well. The NPTF will treat the extracted, contaminated water using air stripping to reduce VOC concentrations in the medial zone to a cumulative risk of less than or equal to 1×10^{-5}, and the treated water will be reinjected into the aquifer. Operation of the NPTF is designed to (a) prevent groundwater contaminated at or above 1,000 µg/L TCE from migrating farther downgradient, and (b) ensure reinjected water from the NPTF contains concentrations of VOCs less than MCLs and that result in a cumulative risk of less than or equal to 1×10^{-5}. Monitoring data from the medial zone will be used to evaluate attainment of RAOs, verify plume containment, and verify radionuclide decay and migration.

Design of the NPTF began pursuant to the decision in the 1997 ESD for early implementation of medial zone remediation (see Section 2.3). Construction of the NPTF started in February 2000 and the facility is scheduled to start routine operations in Fall 2001. The facility is designed to treat groundwater at up to 250 gallons per minute (gpm).

6.1.2 Contingency Remedy for the Medial Zone

The Agencies agreed that radionuclide treatment would not be included in the design for the NPTF, because radionuclides above MCLs are not expected to be present in groundwater routinely treated through the NPTF. Although it is not expected, in the event that radionuclides migrate to NPTF extraction wells in concentrations that would exceed MCLs at the reinjection well, a contingency remedy for the medial zone would be implemented. This contingency remedy would involve operation of the existing ASTU to extract groundwater from a well upgradient of the NPTF, treat the contaminated water through air stripping to remove VOCs, and reinject the treated water in an injection well located upgradient near the hot spot to facilitate sorption of radionuclides onto subsurface soil and rock. Operation of the ASTU as the medial zone contingency remedy would prevent migration of radionuclides that may exceed MCLs in the NPTF reinjection well.

During implementation of the contingency remedy, the NPTF would be operated in such a way as to ensure that the concentration of radionuclides in treated effluent would be less than the applicable MCLs. If the medial zone contingency remedy were implemented, a groundwater monitoring program would be established to monitor the migration of radionuclides.

The NPTF will also treat small quantities of contaminated groundwater (purge water) generated during groundwater monitoring activities conducted during the remedial action. This purge water will originate from all three zones of the contaminant plume. Purge water from the hot spot may contain radionuclides that have concentrations above MCLs. However, this purge water will be added to the NPTF process influent so that the concentration of radionuclides in water reinjected to the aquifer is less than MCLs.

If in the future, cost-effective radionuclide removal technologies become available that could be used for remediation at this site, the Agencies will reassess this component of the amended remedy.

6.2 Amended Remedy

The amended remedy changes two of the three original components for restoring the hot spot and the distal zone of the contaminant plume. The amended remedy components for the hot spot and the distal zone will work in concert with the medial zone component to remediate the entire contaminant plume. Institutional controls and groundwater monitoring will be implemented to support the remedial action. The amended remedy components are:

- ISB at the hot spot, using nutrient injection to create enhanced biodegradation of the VOCs through anaerobic reductive dechlorination. This component will replace the pump-and-treat technology specified for the hot spot under the original remedy.

- MNA in the distal zone. Current estimates indicate that natural attenuation will reduce VOC concentrations to below MCLs within the remedial timeframe. This component will replace the pump-and-treat technology specified for the distal zone under the original remedy.

  Pump-and-treat is identified as the contingency remedy for the distal zone. If evaluations show that the RAOs will not be met within the restoration timeframe, the contingency remedy (i.e., the default remedy from the 1995 ROD) will be implemented or, if the Agencies concur, a more cost-effective remedy will be identified at the time that the contingency remedy is implemented. The contingency remedy also will be invoked if the required monitoring necessary for MNA is not performed. The pump-and-treat system would involve extraction of contaminated groundwater, treatment to reduce the VOCs to below MCLs, and reinjection of treated groundwater. It has been determined that groundwater treated through the NPTF will not be a listed hazardous waste as it will not present an unacceptable risk to human health or environmental receptors. VOC treatment technologies applied in the pump-and-treat facility would be based on concentrations of VOCs measured in the water extracted from the contaminant plume.

6.3 Common Elements

Both the original remedy and the amended remedy use pump-and-treat technology for medial zone remediation, and both remedies use the NPTF for medial zone remediation, as described in Section 6.1.

Both remedies require institutional controls to protect current and future users from health risks associated with groundwater contamination. Consistent with expectations set out in the Superfund regulations (40 CFR 300), neither of the remedies relies exclusively on institutional controls to achieve effectiveness. Detailed information and requirements for institutional controls are addressed in the OU 1-10 ROD (DOE-ID 1999a [DOE/ID-10682]). The only change in institutional controls from the 1995 ROD is the addition of the threshold for non-carcinogens:

- Institutional controls for the entire plume to protect current and future users from exposure to contaminants above MCLs and greater than 1×10^{-4} cumulative carcinogenic risk-based levels and, for non-carcinogens, to a cumulative hazard index of equal to or greater than 1.

Monitoring to ensure the effectiveness of the remedy is a component of both remedies, and has not been changed from the 1995 ROD:

- Groundwater monitoring in accordance with monitoring plans developed as part of the RD/RA. Monitoring data will be used to track the contaminant plume boundary, changes in COC concentration levels, and the attenuation rate to evaluate attainment of RAOs.

The groundwater monitoring program will include, among its activities, monitoring radionuclide concentrations in the hot spot, the medial zone, and the distal zone, as applicable.

6.4 Distinguishing Features

At the hot spot the amended remedy, which uses ISB, is expected to achieve RAOs in about half the time of the original remedy, which uses pump-and-treat technology, because ISB removes the secondary source, while pump-and-treat merely contains it. Both remedies would be expected to achieve RAOs by 2095.

The estimated life-cycle cost in net present value (NPV) for the original remedy is $43 million. The estimated life-cycle cost for the amended remedy is $35 million. The budget for the amended remedy is shown in Table 8-1. Details of both cost estimates are presented in the ROD Amendment Cost Estimate Support Data Recapitulation (INEEL 2001 [EDF-ER-201]).

7. EVALUATION OF ALTERNATIVES

Two remedial alternatives are compared in this section: the original remedy (pump-and-treat at the hot spot and in the distal zone) and the amended remedy (ISB at the hot spot and MNA for the distal zone). Field evaluations indicated that ISB at the hot spot and MNA for the distal zone would better meet the evaluation criteria than pump-and-treat technology. The comparative analysis summarized here evaluates the relative performance of the remedies with respect to EPA's nine evaluation criteria. The nine criteria are grouped into three sets: threshold, primary balancing, and modifying. For each criterion below, the advantages and disadvantages of each remedy are identified.

7.1 Evaluation of Alternatives for the Hot Spot

7.1.1 Threshold Criteria

Threshold criteria are requirements that an alternative must meet to be eligible for selection as the final remedy. The threshold criteria are (1) overall protection of human health and the environment, and (2) compliance with ARARs.

Overall Protection of Human Health and the Environment. This criterion addresses whether an alternative provides adequate protection of human health and the environment and describes how risks posed through exposure pathways are eliminated, reduced, or controlled through treatment, engineering controls, or institutional controls. As a threshold criterion, this must be met for an alternative to be eligible for detailed evaluation and selection.

Both the original remedy of pump-and-treat and the amended remedy, which uses ISB, are protective of human health and the environment by eliminating, reducing, or controlling risks posed by the site through treatment of groundwater contaminants to meet MCLs. The original remedy would provide adequate protection by extracting the contaminated groundwater and treating it to meet MCLs. However, it would contain, rather than degrade, the secondary source. In addition, the pump-and-treat facility would require air emission controls to protect human health. The amended remedy would provide additional protection because the treatment technology would not require contaminated groundwater to be brought to the surface, and it would degrade the secondary source to dechlorinated byproducts.

Compliance with Applicable or Relevant and Appropriate Requirements (ARARs). This criterion requires that remedial actions at CERCLA sites at least attain legally applicable or relevant and appropriate federal and state requirements, standards, criteria, and limitations (collectively referred to as ARARs), as required by Section 121(d) of CERCLA and the NCP Section 300.430(f)(1)(ii)(B). As a threshold criterion, this must be met for an alternative to be eligible for selection.

Both the original remedy, pump-and-treat, and the amended remedy, ISB, would attain their respective ARARs. Drinking water standards will be met through either remedy within the restoration timeframe. For the original remedy, use of pump-and-treat technology would produce an air-emission waste stream that may require air pollution control (APC) equipment to meet the emission standards for VOCs to protect human health. The original remedy will also comply with applicable underground injection control (UIC) standards for reinjection. The amended remedy, ISB, would not require consideration of air emission ARARs, because there will be no air emissions associated with the treatment process. However, the amendments (e.g., sodium lactate) injected into the aquifer during ISB may contain chemical constituents above MCLs. The Agencies have agreed that amendments containing constituents above MCLs may be injected to support aquifer remediation.

7.1.2 Balancing Criteria

The five balancing criteria serve to weigh major trade-offs between alternatives. They are: (1) long-term effectiveness and performance, (2) reduction of toxicity, mobility, or volume through treatment, (3) short-term effectiveness, (4) implementability, and (5) cost.

Long-Term Effectiveness and Permanence. This criterion refers to expected residual risk and the ability of a remedy to maintain reliable protection of human health and the environment over time. This criterion includes consideration of residual risk that will remain on-site following remediation, and the adequacy and reliability of controls.

Both remedies would provide some degree of long-term effectiveness and permanence, but the amended remedy better reduces residual risk: data and modeling indicate that ISB will degrade the secondary source of contaminants within the hot spot, while pump-and-treat has limited ability to remove the secondary source. The original remedy utilizes a reliable technology, pump-and-treat, to permanently remove VOCs from treated groundwater, although the pump-and-treat system would have to be maintained and replaced periodically throughout the duration of the remedial action. The amended remedy would also use a reliable technology, ISB. ISB would permanently destroy the VOCs in situ and is expected to achieve RAOs more quickly than the original remedy. Maintenance and possible system replacement would be required for the amended remedy. However, the ISB injection system is operationally simpler than the original remedy's pump-and-treat facility.

Reduction of Toxicity, Mobility, or Volume through Treatment. This criterion addresses the statutory preference for selecting remedial actions that employ treatment technologies that permanently reduce toxicity, mobility, or volume of the COCs.

Both remedies would reduce toxicity, mobility, or volume of COCs through treatment. Under either remedy, the treatment would be irreversible. The original remedy would permanently reduce VOC toxicity in treated groundwater through air stripping, which would transfer the VOCs to the air or to carbon (if required), and would reduce the mobility of contaminants by hydraulically containing the secondary source area. It also would remove contaminants from the dissolved phase and thus indirectly act to reduce the secondary source. The amended remedy would reduce toxicity by destroying TCE and other chlorinated VOCs in situ and directly reduce the volume of the secondary source. In addition, it would reduce the volume of COCs in less time than the original remedy.

Short-Term Effectiveness. Short-term effectiveness evaluates the amount of time until the remedy effectively protects human health and the environment at the site. It also evaluates any adverse effects that may be posed to workers, the community, or the environment during construction and operation while the remedial activity is being carried out.

Both remedies provide some degree of short-term effectiveness. The amended remedy would provide better short-term effectiveness because the time required for the ISB treatment system to achieve RAOs is anticipated to be about half that of a pump-and-treat system. Risks to workers during the remedial activity would be minimal for the amended remedy, because ISB would completely destroy VOCs underground rather than bringing them aboveground. The original remedy would transfer contaminated water aboveground, where a risk of worker exposure or environmental release would exist. Air stripping under the original remedy could result in impacts to air quality; these would not occur under the amended remedy, since no contaminants would be brought aboveground except for monitoring purposes.

Implementability. The criterion of implementability addresses the technical and administrative feasibility of a remedy from design through construction and operation. Factors such as availability of services and materials, and coordination with other governmental entities, are also considered.

Implementability of both remedies would be high, because equipment, materials, and personnel are readily available, and construction of the treatment system and extraction and reinjection wells use known technologies. However, the amendment injection system is less complicated than a pump-and-treat system. The original remedy could require design consideration of secondary containment and air emissions. As well, it could require additional extraction wells and upgrades to the treatment facility. The amended remedy could require additional injection wells, but would have a simpler and more easily implemented infrastructure overall.

Cost. The estimated life-cycle costs (in NPV using a 7% discount rate) for the two remedies at the hot spot are $2.72 million for the original remedy ($1.1 million for capital costs, and $209 thousand yearly for operations and maintenance [O&M]), and $1.48 million for the amended remedy ($106 thousand for capital costs, and $205 thousand yearly for O&M). Calculation of the NPV estimates assumed a 30-year operating period for the original remedy and 15 years of operations for the amended remedy. The budget for the amended remedy is shown in Table 8-1. Details of both cost estimates are presented in the ROD Amendment Cost Estimate Support Data Recapitulation (INEEL 2001 [EDF-ER-201]).

7.1.3 Modifying Criteria

Modifying criteria are fully considered after public comment on the Proposed Plan is received. The two modifying criteria are (1) state acceptance and (2) community acceptance. The modifying criteria are used in final evaluation of remedial alternatives and are equal in importance to the balancing criteria.

State Acceptance. State acceptance is demonstrated by IDEQ concurrence with the selected remedial alternative and signature of this ROD Amendment. The IDEQ was involved in the development and review of the ESD, the FDR, and the Proposed Plan (as cited in Table 2-4), as well as this ROD Amendment and other project activities including the public meetings.

Community Acceptance. For community acceptance, the factors that are considered include which elements of the remedial alternatives interested persons in the community support, have reservations about, or oppose.

The Responsiveness Summary (Part III) portion of this ROD Amendment documents the full range and content of the public comments received regarding the recommended action.

Overall, the amended remedy is strongly supported, especially in its use of a more cost-effective technology. Several comments sought additional general information on ARARs, institutional controls, and achievement of RAOs. One written comment included numerous questions on how the amended remedy will deal with radionuclides; this additional detail was provided in the Responsiveness Summary (see, for example, responses to Comments 7, 10, 21, 23, and 26 in Section 13), based on information summarized in Section 5.2. Several commenters asked how sufficient amendments could be injected to support ISB, whether the dechlorination breakdown products could pose risk, and whether new risk could be introduced to the aquifer from potential contaminants that may be present in the amendments. These concerns have been addressed by responses to Comments 12, 17, 19, and 22 in Section 13, based on information in Section 8.1.1.

No commenters preferred the original remedy of pump-and-treat to the amended remedy of ISB. The single topic mentioned by the greatest number of commenters was praise for the Agencies' use of research and testing to develop an innovative, more cost-effective remedy (see Comments 1, 15, and 27 in Section 13).

7.2 Evaluation of Alternatives for the Distal Zone

7.2.1 Threshold Criteria

Threshold criteria are requirements that an alternative must meet to be eligible for selection as the final remedy. The threshold criteria are (1) overall protection of human health and the environment, and (2) compliance with ARARs.

Overall Protection of Human Health and the Environment. This criterion addresses whether an alternative provides adequate protection of human health and the environment and describes how risks posed through exposure pathways are eliminated, reduced, or controlled through treatment, engineering controls, or institutional controls. As a threshold criterion, this must be met for an alternative to be eligible for detailed evaluation and selection.

Both the original remedy, pump-and-treat, and the amended remedy, MNA, are protective of human health and environment by eliminating, reducing, or controlling risks posed by the site through treatment or natural attenuation of groundwater contaminants. The original remedy would provide adequate protection by extracting the contaminated groundwater and treating it to meet MCLs. However, the pump-and-treat facility would require air emission controls to protect human health. The amended remedy would provide better protection because natural attenuation would not require contaminated groundwater to be brought to the surface; hence, no air emission controls would be required.

Both the original remedy of pump-and-treat and the amended remedy, MNA, are projected to meet RAOs within the restoration timeframe (by 2095). For cost estimating purposes, the 1995 ROD assumed pump-and-treat technology would meet RAOs after 30 years.

Under the amended remedy, the plume is expected to reach its maximum extent (30% growth) in 2027. However, at its largest, the plume will remain well within the INEEL's boundaries. Furthermore, institutional controls will prevent exposure of potential users to contaminated groundwater during the restoration period.

Compliance with Applicable or Relevant and Appropriate Requirements (ARARs). This criterion requires that remedial actions at CERCLA sites at least attain legally applicable or relevant and appropriate federal and state requirements, standards, criteria, and limitations (collectively referred to as ARARs), as required by Section 121(d) of CERCLA and NCP Section 300.430(f)(1)(ii)(B). As a threshold criterion, this must be met for an alternative to be eligible for selection.

For the original remedy, use of pump-and-treat technology would produce an air-emission waste stream that may require APC equipment to meet the emission standards for VOCs to protect human health. The amended remedy, MNA, would not require consideration of air emission ARARs, because there would be no air emissions associated with the natural attenuation process.

7.2.2 Balancing Criteria

The five balancing criteria serve to weigh major trade-offs among alternatives. They are: (1) long-term effectiveness and performance, (2) reduction of toxicity, mobility, or volume through treatment, (3) short-term effectiveness, (4) implementability, and (5) cost.

Long-Term Effectiveness and Permanence. This criterion refers to expected residual risk and the ability of a remedy to maintain reliable protection of human health and the environment over time. This criterion includes consideration of residual risk that will remain on-site following remediation, and the adequacy and reliability of controls.

Both remedies would provide some degree of long-term effectiveness and permanence. The original remedy utilizes a reliable technology, pump-and-treat, to permanently remove VOCs from extracted groundwater, although the pump-and-treat system would have to be maintained and replaced periodically. The original remedy would control plume migration in the distal zone. The amended remedy, using MNA, will permanently dechlorinate the VOCs in situ through natural degradation processes. However, modeling projects that growth of the distal zone of up to 30% might occur, with the contaminant plume reaching its maximum size in about 2027. The amended remedy is expected to require a longer period of time to achieve RAOs than the original remedy would. Both remedies require the NPTF to be operational in order to contain and treat upgradient contaminants within the medial zone.

Reduction of Toxicity, Mobility, or Volume through Treatment. This criterion addresses the statutory preference for selecting remedial actions that employ treatment technologies that permanently reduce toxicity, mobility, or volume of the COCs.

Under either remedy, the reduction of toxicity, mobility, or volume would be irreversible. The original remedy would permanently reduce VOCs in groundwater through air stripping, but would transfer contaminants to carbon or air rather than destroy them. It would reduce plume mobility in the distal zone. The amended remedy, MNA, does not reduce toxicity, mobility, or volume of contaminants through treatment but allows natural degradation processes to achieve the same goals. Modeling suggests that growth of the distal zone of up to 30% might occur during the first quarter of the remediation period. The contaminant plume is projected to reach maximum size in about 2027 as a result of downgradient movement, and then decrease in size as attenuation continues.

Short-Term Effectiveness. Short-term effectiveness evaluates the amount of time until the remedy effectively protects human health and the environment at the site. It also evaluates any adverse effects that may be posed to workers, the community, or the environment during construction and operation while the remedial activity is being carried out.

Both remedies provide some degree of short-term effectiveness. The original remedy would transfer contaminated water aboveground, where a risk of exposure to workers, the community, or the environment would exist. Air stripping under the original remedy could result in impacts to air quality; these would not occur under the amended remedy, because MNA takes place underground. The amended remedy, MNA, would provide better short-term effectiveness because, other than through monitoring activities common to both remedies, MNA would not have a potential to expose workers, the community, and the environment to contaminants. Both the original remedy of pump-and-treat and the amended remedy, MNA, are projected to meet RAOs within the restoration timeframe (by 2095). For estimating purposes, the 1995 ROD assumed pump-and-treat technology would meet RAOs after 30 years.

Implementability. The criterion of implementability addresses the technical and administrative feasibility of a remedy from design through construction and operation. Factors such as availability of services and materials, and coordination with other governmental entities, are also considered.

Implementability of the original remedy would be high, because equipment, materials, and personnel are readily available, and construction of the treatment system and extraction and reinjection wells use known technologies. However, design of the facility would require consideration of secondary containment and air emissions. Implementability of the amended remedy, MNA, would be higher because it requires no special equipment or material and would use the existing monitoring system, which is sufficient to cover anticipated plume growth, as well. MNA also requires no construction and operation infrastructure other than monitoring wells.

Cost. The estimated life-cycle costs (in NPV using a 7% discount rate) for the remedies for the distal zone are $4.45 million for the original remedy ($2.1 million for capital costs, and $400 thousand yearly for O&M), and $0.71 million for the amended remedy ($0 for capital costs, and $77 thousand yearly for O&M). Calculation of the NPV estimates assumed a 30-year operating period for both remedies. The MNA cost estimate assumes that the groundwater monitoring program would require additional analytes beyond those required for monitoring under the pump-and-treat technology of the original remedy.

The budget for the amended remedy is shown in Table 8-1. Details of both cost estimates are presented in the ROD Amendment Cost Estimate Support Data Recapitulation (INEEL 2001 [EDF-ER-201]).

7.2.3 Modifying Criteria

Modifying criteria are fully considered after public comment on the Proposed Plan is received. The two modifying criteria are (1) state acceptance and (2) community acceptance. The modifying criteria are used in final evaluation of remedial alternatives and are equal in importance to the balancing criteria.

State Acceptance. State acceptance is demonstrated by IDEQ concurrence with the selected remedial alternative and signature of this ROD Amendment. The IDEQ was involved in the development and review of the ESD, the FDR, and the Proposed Plan (as cited in Table 2-4), as well as this ROD Amendment and other project activities, including the public meetings.

Community Acceptance. For community acceptance, the factors that are considered include which elements of the remedial alternatives interested persons in the community support, have reservations about, or oppose.

The Responsiveness Summary (Part III) portion of this ROD Amendment documents the full range and content of the public comments received regarding the recommended action.

Overall, the amended remedy is strongly supported, especially for its cost-effectiveness. Several comments sought additional general information on ARARs, institutional controls, and achievement of RAOs. One written comment included questions on whether the amended remedy would need to deal with radionuclides in the distal zone; this additional detail was provided in the Responsiveness Summary (see, for example, responses to Comments 10, 23, and 26 in Section 13), based on the information summarized in Section 5.2.

No commenters preferred the original remedy of pump-and-treat to the amended remedy MNA. The single topic mentioned by the greatest number of commenters was praise for the Agencies' use of

research and testing to develop an innovative, more cost-effective remedy (see Comments 1, 15, and 27 in Section 13).

7.3 Tabular Ranking of Alternatives

Tables 7-1 and 7-2 show how the two remedies compare under each criterion. The comparison is based on remediation of TCE. Remedial actions that reduce TCE will act to reduce the other VOC COCs as well. The radionuclide COCs are expected to meet RAOs through decay and adsorption before the end of the remedial action timeframe.

Table 7-1. Comparative analysis of alternatives for the hot spot.[a]

Criteria	Original Remedy (Pump-and-Treat)	Amended Remedy (ISB)
THRESHOLD CRITERIA		
Overall Protectiveness		
Human Health Protection	Reduces aquifer VOC concentrations to MCLs and will contain the secondary source. Management of water brought to the surface for treatment will require controls to ensure worker safety and off-gas treatment.	More protective because it will not only destroy TCE concentrations in situ but will also degrade the secondary source. In situ treatment eliminates need for controls to insure worker safety related to handling and treatment of contaminated water.
Environmental Protection	The only environmental risks known to be associated with this action are from air emissions during treatment.	There are no groundwater discharges to the surface and, thus, no environmental risks are known to be associated with this action.
Compliance with ARARs		
Chemical-Specific ARARs	Meets all ARARs of Federal and State environmental statutes.	Meets all ARARs of Federal and State environmental statutes.
Location-Specific ARARs	No location-specific ARARs.	No location-specific ARARs.
Action-Specific ARARs	Meets all action-specific ARARs. System will meet all air release standards for off-gas as well as applicable UIC standards for reinjection.	Meets all action-specific ARARs. Amendments will be injected in accordance with Idaho Administrative Procedures Act (IDAPA) 37.03.03.050.01.
PRIMARY BALANCING CRITERIA		
Long-Term Effectiveness and Permanence		
Magnitude of Residual Risk	The ability to remove the secondary source is limited.	Current data and modeling indicate that ISB will degrade the secondary source.
Adequacy and Reliability of Controls	Expected to be reliable for at least the first 30 years. Long-term permanence will require periodic system replacement.	ISB is reliable and is expected to be completed in a shorter period of time relative to the original remedy of pump-and-treat. The controls for the amendment delivery system are simple relative to the original remedy's pump-and-treat facilities.
Reduction of Toxicity, Mobility, or Volume through Treatment		
Treatment Process Used and Materials Treated	Removes VOCs in groundwater by air stripping and will result in VOC media transfer (rather than destruction).	Removes TCE in groundwater by ISB without media transfer, and will degrade the secondary source.
Amount of Hazardous Materials Destroyed or Treated	Removes VOCs from the hot spot to prevent MCLs from being exceeded in the medial zone.	Removes TCE from the hot spot to prevent MCLs from being exceeded in the medial zone.
Degree of Expected Reductions in Toxicity, Mobility, or Volume	Typically achieves 99% reduction in toxicity of extracted groundwater.	Current data and modeling indicate that ISB achieves complete dechlorination within the hot spot and reduces volume through degradation of the secondary source.
Degree to which Treatment is Irreversible	Irreversible process.	Irreversible process.
Type and Quantity of Residuals Remaining After Treatment	Secondary source contamination may remain for a longer period of time. Carbon used in off-gas treatment (if required) will require disposal.	Will degrade the secondary source over a shorter period of time than the original remedy. No residuals will remain from ISB because breakdown is complete.

Table 7-1. (continued).

Criteria	Original Remedy (Pump-and-Treat)	Amended Remedy (ISB)
Short-Term Effectiveness		
Protection of Community During Remedial Actions	Air emissions increase the risk to the community. Institutional controls will prevent risk to the community from ingestion of contaminated groundwater.	Institutional controls will prevent risk to the community from ingestion of contaminated groundwater.
Protection of Workers During Remedial Actions	Protection required against dermal contact and vapor inhalation and operation. Institutional controls will prevent risk to workers from ingestion of contaminated groundwater and risks from air emissions.	The amendments are food-grade commodities.
Environmental Impacts	Off-gas may impact air quality.	No environmental impacts.
Time Until Remedial Action Objectives are Achieved	Expected to achieve hot spot RAOs for VOCs by 2025–2095, and for the radionuclide COCs by 2095.	Anticipated to achieve hot spot RAOs for VOCs in roughly half the time required for pump-and-treat, and for the radionuclide COCs by 2095.
Implementability		
Ability to Construct and Operate the Technology	Mature technology that is easily implementable.	Implementable with simpler infrastructure than required for pump-and-treat.
Ease of Undertaking Additional Remedial Actions, if Necessary	Additional extraction wells and upgrades to treatment facility may be added as necessary.	Additional amendments and injection wells may be added as needed.
Ability to Monitor Effectiveness of Remedy	Treatment system is easily monitored to determine effectiveness.	Treatment system is easily monitored to determine effectiveness.
Ability to Obtain Approvals and Coordinate with other Agencies	Need to demonstrate compliance with air standards, RCRA secondary containment requirements, and UIC regulations.	Amendments must be injected in accordance with UIC regulations (IDAPA 37.03.03.050.01).
Availability of Necessary Equipment and Specialists	Equipment, materials, and personnel to operate systems are readily available.	Equipment, materials, and personnel to operate are readily available.
Availability of Prospective Technologies	Available.	Available.
Cost[b]		
Estimated Cost	$2.72 million[c]	$1.48 million[d]

a. The remedial actions evaluated here to reduce TCE will act to reduce the other chlorinated COCs as well.

b. Costs are in 1999 dollars in NPV using a 7% discount rate. NPV estimates assumed a 30-year operating period for the original remedy and 15 years of operations for the amended remedy.

c. The estimated cost of the original remedy comprises $1.1 million for capital costs, and $209 thousand yearly for O&M.

d. The estimated cost of the amended remedy comprises $106 thousand for capital costs, and $205 thousand yearly for O&M.

Table 7-2. Comparative analysis of alternatives for the distal zone.

Criteria	Original Remedy (Pump and Treat)	Amended Remedy (Monitored Natural Attenuation)
THRESHOLD CRITERIA		
Overall Protectiveness		
Human Health Protection	Reduces aquifer VOC concentrations to MCLs. Management of water brought to the surface for treatment will require controls to ensure worker safety.	More protective because it will not only destroy contaminants in situ (by natural biodegradation processes), it will also reduce aquifer VOC concentrations to MCLs within the restoration timeframe. In situ degradation eliminates the need for controls to insure worker safety related to handling and treatment of contaminated water. Plume growth of up to 30% is expected before attenuation operates to reduce plume size to meet distal zone RAOs. Although MNA may take longer to meet RAOs, it will be accomplished in situ, which will prevent exposure to COCs.
Environmental Protection	The only environmental risks known to be associated with this action are from air emissions during treatment.	There are no groundwater discharges to the surface and, thus, no environmental risks are known to be associated with this action.
Compliance with ARARs		
Chemical-Specific ARARs	Meets all ARARs of Federal and State environmental statutes.	Meets all ARARs of Federal and State environmental statutes.
Location-Specific ARARs	No location-specific ARARs.	No location-specific ARARs.
Action-Specific ARARs	Meets all action-specific ARARs. System will meet all air release standards for off-gas as well as applicable UIC standards for reinjection.	No action-specific ARARs.
PRIMARY BALANCING CRITERIA		
Long-Term Effectiveness and Permanence		
Magnitude of Residual Risk	Results in low residual risk by removal of aqueous phase VOCs.	Results in low residual risk due to the removal of VOCs by dechlorination.
Adequacy and Reliability of Controls	Expected to be reliable for at least the first 30 years. Requires NPTF to be operational and functional to contain and treat upgradient contaminants within the medial zone.	MNA is reliable. However, it is expected to require a longer period of time relative to the original remedy of pump-and-treat. Other than monitoring, which is common to both remedies, no systems or infrastructure are required. Requires NPTF to be operational and functional to contain and treat upgradient contaminants within the medial zone.
Reduction of Toxicity, Mobility, or Volume through Treatment		
Treatment Process Used and Materials Treated	Removes VOCs in groundwater by air stripping and will result in VOC media transfer (rather than destruction).	Removes VOCs through natural dechlorination processes without media transfer.
Amount of Hazardous Materials Destroyed or Treated	Removes VOCs to meet RAOs for the distal zone.	Dechlorinates VOCs to meet RAOs for the distal zone.
Degree of Expected Reductions in Toxicity, Mobility, or Volume	Typically achieves 99% reduction in toxicity of extracted groundwater.	Achieves complete dechlorination through natural degradation processes. Plume growth of up to 30% is expected before attenuation operates to reduce plume size.
Degree to which Treatment is Irreversible	Irreversible process.	Irreversible process.

Table 7-2. (continued).

Criteria	Original Remedy (Pump and Treat)	Amended Remedy (Monitored Natural Attenuation)
Reduction of TMV (continued)		
Type and Quantity of Residuals Remaining After Treatment	Carbon used in off-gas treatment (if required) will require regeneration or disposal.	No detectable residuals remain.
Short-Term Effectiveness		
Protection of Community During Remedial Actions	Air emissions increase the risk to the community. Institutional controls will prevent risk to the community from ingestion of contaminated groundwater.	Institutional controls will prevent risk to the community from ingestion of contaminated groundwater.
Protection of Workers During Remedial Actions	Protection required against dermal contact and vapor inhalation during construction and operation. Institutional controls will prevent risk to workers from ingestion of contaminated groundwater and risks from air emissions.	Will not increase potential risk to workers because it takes place in situ.
Environmental Impacts	Off-gas may impact air quality.	No environmental impacts.
Time Until Remedial Action Objectives are Achieved	Expected to achieve distal zone RAOs by 2025–2095.	Anticipated to meet distal zone RAOs by 2095.
Implementability		
Ability to Construct and Operate the Technology	Mature technology that is easily implementable.	MNA requires no construction and operation other than monitoring, which is common to both remedies.
Ease of Undertaking Additional Remedial Actions, if Necessary	Additional extraction wells and upgrades to treatment facility may be added as necessary.	The contingency remedy is pump-and-treat (the 1995 ROD default remedy).
Ability to Monitor Effectiveness of Remedy	Treatment system is easily monitored to determine effectiveness.	Treatment system is easily monitored to determine effectiveness. Plume growth of up to 30% is within the existing monitoring system coverage area.
Ability to Obtain Approvals and Coordinate with other Agencies	Need to demonstrate compliance with air standards, RCRA secondary containment requirements, and UIC regulations.	No additional approvals required.
Availability of Necessary Equipment and Specialists	Equipment, materials, and personnel to operate systems are readily available.	Does not require any special equipment or material.
Availability of Prospective Technologies	Available.	Available.
Cost[a]		
Estimated cost	$ 4.45 million[b]	$ 0.71 million[c]

a. Costs are in 1999 dollars in NPV using a 7% discount rate. The NPV estimates assumed a 30-year operating period for both remedies.

b. The estimated cost of the original remedy comprises $2.1 million for capital costs, and $400 thousand yearly for O&M.

c. The estimated cost of the amended remedy comprises $0 for capital costs, and $77 thousand yearly for O&M.